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Abstract

**Development of Rod and Hollow Type Swaged UO_2 Fuel Elements
and Some Irradiation Behaviors**

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Fabrication processes of rod and hollow type swaged UO_2 fuel elements has been developed in connection with its irradiation behaviors.

As the feed, highly dense UO_2 powders were prepared by ADU-process. The precipitation of ADU under a particular condition was necessary, while for the firing in hydrogen of higher oxides (UO_3 and/or U_3O_8) relatively low temperatures of 1,200 - 1,750°C sufficed.

The means to realize the swaging effect including close-packing and particles-bonding are small reduction in area by each pass of swaging and much pass-number in given total reduction. A swaging machine designed to have successive sets of dies tandem was used in order to enlarge the swaging effect. For cold-swaged fuel rods, the maximum density was 93% of the theoretical. Straightness was better than 0.25 mm/m. Diametral variation was within ± 0.02 mm. The minimum thickness of the stainless steel sheaths of the rods swaged satisfactorily was 0.25 mm. Results of burst tests and autoclave tests on stainless steel sheaths and zircaloy-2

sheaths of swaged UO_2 fuel rods were not inferior to as-received sheaths before swaging.

Fabrication processes for hollow-type UO_2 fuel elements were to fill the annular space between the outer and inner tubes with UO_2 powder, to insert a mandrel into the hollow center, to swage the assembly, and finally to remove the mandrel. Hollow-type swaged fuel elements of 36 mm in outer diameter and 800 mm in length were fabricated without any defect in sheaths. Density of the UO_2 compact was $91 \pm 0.5\%$ of the theoretical. The maximum variation in thickness of annular layer of the UO_2 compact was within ± 0.1 mm.

An irradiation test of cold- and hot-swaged fuel rods was performed under the heat generation rate of 10 - 13 KW/ft and the burnup of 2,700 MWD/T- UO_2 . The swaged fuel rods were highly resistive against thermal shock during the irradiation. The temperatures during the irradiation were $1,300 - 1,500^\circ\text{C}$ at the center and 55°C at the surface. Sintering was recognized even in the UO_2 portion near the sheath, where temperature during the irradiation might not be enough to produce sintering phenomenon in the thought of normal sintering. The behavior of UO_2 fuel rods at high temperatures near or at the melting point was studied by a center line heating experiment at out-of-pile.

In an appendix, investigation of vibratory compaction technique using crushed UO_2 powder obtained from sintered pellets containing burnable poisons is described by Sumitomo Electric Industries, Ltd.